Synopsis for Ph.D. Thesis

“Ambient Noise Tomography and Seismicity of South East Deccan Volcanic Province of India.”

Submitted to

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Title: "Ambient Noise Tomography and Seismicity of South East Deccan Volcanic Province of India."

Abstract:

Killari in SE Deccan Volcanic province, rocked by a 6.2 magnitude earthquake in 1993, and is also site of irregular minor earthquakes. This is one of the appropriate site to study the intraplate earthquakes in India. This study is mainly focused to image the shallow subsurface structure beneath the intraplate earthquake source region of Killari and its surrounding region based upon the ambient noise tomography and monitor the seismicity of this region. We are purposing to use network of around 15 Broadband seismic stations to investigate the shallow subsurface structure image and seismicity, to understand the relationship between the seismicity and crustal structure in South East Deccan volcanic Provence region This study will help to understand the seismic hazard in an intraplate seismic area.

Keywords: Ambient Noise Tomography, Seismicity, Deccan Volcanic Province.

Introduction:

We have established the 15 Broadband seismic stations network in the vicinity of Killari region. This region had witnessed a 6.2 magnitude intraplate earthquake in the year 1993, since then numerous geological and geophysical surveys were carried out. As most of the seismological surveys were carried out on the aftershocks of 1993 quake, it resolved the structure in the vicinity of it. The regional structural configuration needs to be understood in more detailed way. Hence, we propose to conduct a comprehensive study to understand the relation between seismicity and shallow sub-surface crustal properties of the intraplate seismic zone of intraplate seismicity around Killari and adjoining regions of South East Deccan Volcanic Province (SEDVP). The focus of the present study would be study the local seismicity and on evaluating the shallow crustal structure of the Killari and adjoining regions of the South East Deccan Volcanic Province (SEDVP) using the ambient noise tomography.

Geology of Study Area:

The Deccan Volcanic Province (DVP) is remarkable for geo-events in the geologic history of the Indian plate took place an important position in global tectonic models, The DVP forms one of the world's most important Large Igneous Provinces (Chenet et al., 2009). The Deccan Volcanic Province (DVP) is the one of the largest volcanic eruption with an area of 500,000 km2 spreading the part of Gujarat, Madhya Pradesh and state of Maharashtra (Krishnan 1960). During the cretaceous event the Indian plate witnessed three continental flood basalt provinces: Rajmahal, Sylhet and Deccan traps. Among them, the Deccan traps are the most extensive; best exposed Large Igneous Provinces, covering a vast tract of the Deccan plateau in the western and central parts of India.

The part of DVP is bounded by four prominent tectono-structural units. These are the north- south trending arcuate Panvel Flexure to the west of the Western Ghats, The east-west trending Narmada-Tapti Rift System to the north, The north-south trending Cambay Rift System to the northwest and the northwest-southeast trending Godavari rift to the southeast of the main DVP.

The Deccan Plateau divided into followings four parts

1. Eastern Deccan Plateau (EDP)
2. Saurashtra Plateau (SP)
3. Malwa Plateau(MP)
4. Main Deccan Plateau (MDP).

The Main Deccan Plateau lies South of Narmada - Son valley having extensive coverage an area and their thickness of 3.5 km. The Eastern Deccan Plateau is represent in the northeastern part of MPD in central India and having a thickness of 900 m and covering an area is 29,400 km2. The Saurashtra Plateau occurs in Kachhh region and Saurashtra of the western Gujarat and coverage an area about 61,000Km2. The Malwa Plateau lies over the North Narmada valley having a thickness is 500 m including the aerial extend about 80,000 Km2. (Khosla and Sahni, 2003; Khosla and Verma, 2015; Verma et al., 2016, 2017; Kapur and Khosla, 2018). The Deccan plateau is made up of solidification of flood basalt. The lava flowed great distances towards east and south to form the largest terrestrial flood cover extending nearly half a million square km between latitudes 16-24°N and longitudes 70- 77°E. There are several studies in the past to evaluate the lithospheric velocity structure of the Indian Peninsula using body waves and surface waves from regional and teleseismic earthquakes (Dube et al., 1973; Gupta et al., 2003(a,b srinagesh et al., 2012, kaplay et al., 2013).

The thickness of DVP is highest at the western margin and as we move in the direction ofthe east, the thickness decreases (Patro and Sarma, 2007) and the thickness of the Deccan Trap towards the East of around 196 m in Nanded and further east the Archean Granites are exposed near Kinwat region of Maharashtra. To generate such huge amounts of basaltic melt, generally a huge thermal anomaly is required and mantle plume models are invoked (White and McKenzie 1989).

There are two possible theories regarding how a plume interacts with the Continental Lithosphere; one is the active mantle hypothesis of Morgan (1971, 1981) wherein it is considered that Mantle plumes drive plates and initiates continental breakup by doming and cracking the continents and pushing the continents apart. The other is a passive model where plume does not result in breaking up continents except for the fact that it result in rapid out-pouring huge amounts of flood basaltic magma. It is speculated that the Reunion Hotspot was the source of thermal energy in generating huge volumes of flood basalts when Indian plate passed over it during Cretaceous-Tertiary times (Morgan, 1981; Richards et al., 1989; Campbell & Griffiths,1990).

The mantle plume model however is challenged by (Sheth 1999, Sheth et al., 2003) describing that the Continental Flood basalts have formed due to rifting based on geochemistry and geochronology and Petrology and does not necessarily need a plume model to support the generation of Deccan Basalts.

Review of Literature:

The crustal composition of the Deccan Volcanic Province is mafic intermediate and for East Dharwar craton (EDC) is Felsic intermediate. The crustal variation of crust shows a gradient Moho with the presence of magmatic material of Deccan Volcanic Province region. On the other side of EDC, the Moho is sharp and lacks an under plated layer at the crust-mantle boundary (CMB). The crustal thickness of DVP is varying from 34 - 40 km and the EDC is about 32 -34 km; this suggests that the crustal thickness is higher at DVP than at EDC (Kumar, et al., 2000 ; Rai et al., 2003; Gupta et al., 2003 (a,b)).

Deep electrical sounding and Magnetotelluric (MT) soundings methods study shows that the thickness of Deccan Volcanic Province in the range of 220 to 1200 m from eastern to western region (Bhaskar Rao et al., 1995). Seismological studies suggested that some of the active lineaments are present at DVP region like Kurduwadi lineament, The NW-SE trending kadam fault lies to the north at distance of 90 km and Latur lineament about 100 km to the south (GSI, 2000).

Study of the seismotectonic (Gaokar et. al, 2007) revealed that the area is spanned by regional Bouger gravity contours of – 60 and – 70 mgal with the average negative gradient of 0.2 mgal/km. Some of major earthquakes like the Kilari earthquake of magnitude 6.3 (Sept 1993) with the focal depth of this earthquake is varied from 5 to 12.3 km.

Objectives of Research:

The objective of this study is to investigate the shallow subsurface structural image of the South East Deccan Volcanic Province (SEDVP) of India. We shall utilize noise tomography technique on the seismic noise acquired on spread network in and surround region of Killari of SEDVP

The principle of the proposed work is to image the subsurface structure and to indicate the high resolution velocity maps of shallow sub-surface of the region and it applicable to draw the potential map of seismic imaging for SEDVP region. It also can be extended to study the subsurface structures in the extreme condition where we face the challenge of using explosive source which been an area of heightened research interests. The high resolution seismic image is highly applicable for mineral exploration and hazard assessment based upon the findings from the ambient noise tomography and seismicity of SEDVP region.

Methodology to be adopted:

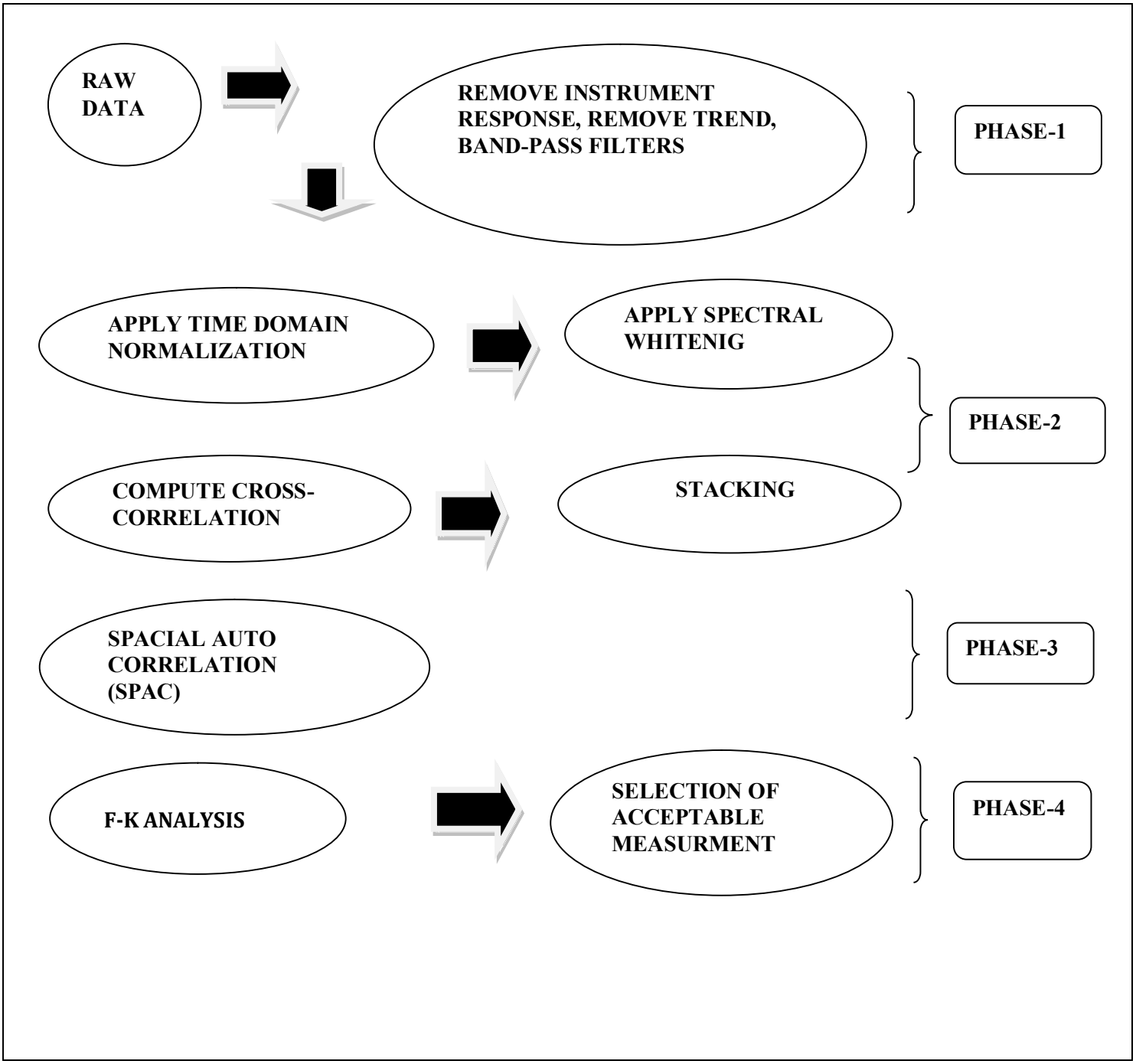
- **Ambient Noise Tomography:**

The application of study from Ambient Noise Tomography given the successful results of study region of California South Korea, Tibet, Europe, Newzealand (Bensen et al., 2007) as well as in south India shield (Borah et al., 2014; Sion Kumari and Gupta, 2023 JGSI under review). The data processing to use the Ambient Noise Tomography to locate surface wave dispersion measurement are dived into four step phases that are applied such as (Bensen et al., 2007)

1] Signal Station data preparation
2] Cross-Correlation & Temporal stacking
3] Measurement of dispersion curves
4] Quality Control

Above are steps for data processing to compute tomography for group or phases speed map & inversion for Vs earth model of the region. Ambient noise tomography is applied to Rayleigh wave and Love wave.

This is the flow chart for Ambient Noise Tomography data processing



Following steps are phase one data processing which range from individual station data processing (step-1), cross-correlation and stacking data from station - pairs (steps-2), Measuring surface wave dispersion (step-3) and data quality control apply and measure the dispersion curve (step-4).The first phase of data processing is performed on wave from data from each single station.

Following are different method to identify and remove the earthquakes signals

1) The first method is known as one-bit normalization, in one-bit normalization is all depending positive amplitude replacing is with 1 and all negative amplitude replacing is with -1. The one-bit normalization is applicable to increasing Signal-to- Noise ratio (SNR).

2) Second method is clipping and threshold equal to RMS amplitude of signal for a day file.

3) Third Method is to identify the event and removal the amplitude which is above the critical threshold within the 30 min of waveform and are set to be zero.

4) Fourth method is to apply the mean normalization in the time domain normalization.

Importance of study:

International status:

The globally spared flood basalt are the Siberian Traps , the Columbia river plateau of North America, the Deccan traps of flood basalt in central India and larger Igneous Province (LIP) of Canada. The Flood basalt are due to the mechanism of continental rifting and decompressed melting and caused by low velocity it can be spared of large area flood basalt province (Leitch et al., 2001).

The flood basalt is the result of volcanic eruption, the existing theories suggest that the flood basalt have been attributed to mantle plume hotspot. For the formation of flood basalt large amount of thermal anomaly is necessary and mantle plume models are invoked (White and McKenzie 1989, Campbell and the Griffiths 1990, Duccan and Riccher's 1991; Kumar and Gupta, 2022).

National Status:

In the Indian region intraplate earthquakes occurs at various places like the Bhuj earthquake (Kayal et al., 2002), the Latur earthquake (Rajendran et al. 1996, Kayal et al., 1996). The Latur earthquakes foreshock and aftershock studies shows that the Latur region is under compressional zone and fault plane study gives the region is reverse fault (Baumbach et al., 1994, Srinagesh et. al. 2012, kaplay et al. 2013).

Significance of the study:

The present study would be useful to understand the upper crustal configuration at a high resolution in the study region. As the seismicity is observed in only few of places, we plan to use noise to model the high resolution upper crustal structure as this would enable us further to understand the seismicity in the region in particular and genesis of the region in general.

Proposed work Plan:

1st year:

- Course work
- Literature review survey
- Data collection
- Preliminary data analysis

2nd year: Data collection, analysis and processing of Preliminary results.

3rd year: Interpretation of preliminary results and finalization of the results, scientific papers and thesis writing.

- Interpretation of Data processing
- Presentation in Seminars: At national and international level.
- Publication of research papers: In National and International Journals.
- Writing and Submission of Thesis: The thesis will be written after the interpretation of data and accomplishment of objectives will be submitted at the end of the third year.

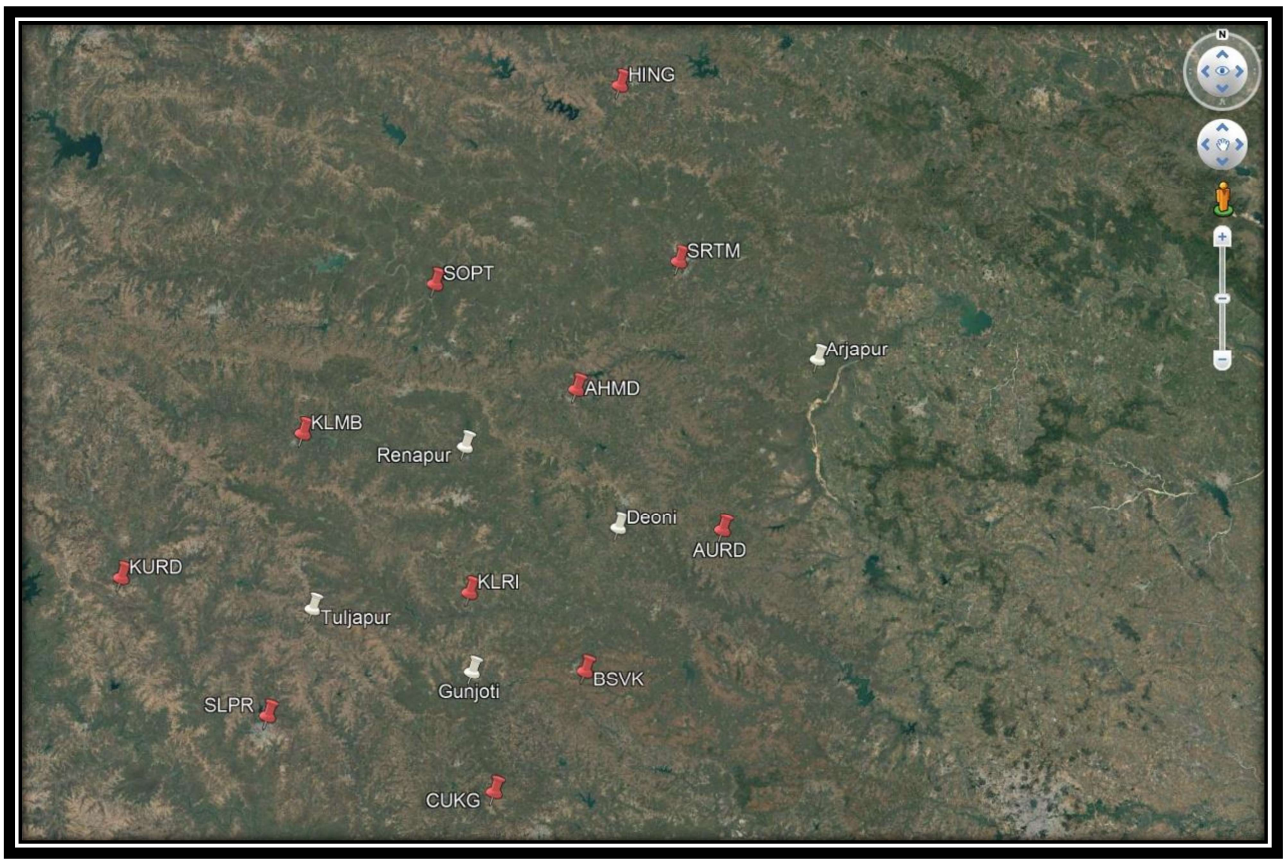


Figure : The study region showing the location of Seismic stations of SEDVP region which can be used in the proposed work.

Sr. No.	Station Code	Station Name	Latitude	Longitude	Elevation (Meter)
01	AHMD	Ahmedpur	18.69557	76.94544	535
02	AURD	Aurad	18.25360	77.42765	487
03	BSVK	Basavakalyan	17.81447	76.97076	614
04	CUKG	Gulbarga	17.43422	76.67121	486
05	HING	Hingoli	19.65430	77.09431	413
06	KLMB	Kalamb	18.56274	76.03832	605
07	KURD	Kurduwadi	18.10283	75.43527	464
08	SLPR	Solapur	17.67031	75.92297	403
09	SOPT	Sonpeth	19.02896	76.47590	328
10	SRTM	Nanded	19.09806	77.28790	316
11	DEON	Deoni	18.25961	77.08094	608
12	ARJP	Arjapur	18.78733	77.74452	403
13	TUJP	Tuljapur	18.00981	76.07148	665
14	RENP	Renapur	18.52036	76.57671	630
15	GUNJ	Gunjoti	17.81586	76.59918	587

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